IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of	) Attorney Docket No.: **ICB0224**
Ulrich DURR et al.	) Confirmation No.: 3109
Serial No.: 10/550,536	) Group Art Unit: 3742
Filed: September 22, 2005	) Examiner: Samuel M. Heinrich
For: LASER DEVICE FOR DRILLING HOLES IN COMPONENTS OF A FLUID INJECTION DEVICE	)

DECLARATION UNDER 37 C.F.R. § 1.132

MAIL STOP: AMENDMENT
U.S. Patent and Trademark Office
Customer Service Window
Randolph Building
401 Dulany Street
Alexandria, VA 22314

Sir:

1. I, V. Romano, state that I am an expert in the field of the above-captioned application as evident from my Curriculum Vitae, which is attached herewith as "Exhibit A."
I am a researcher at the University of Bern and at the Bern University of Applied Sciences and independent from LASAG. My relationship to LASAG is limited to publicly funded research projects. I am not receiving any compensation for this testimony.

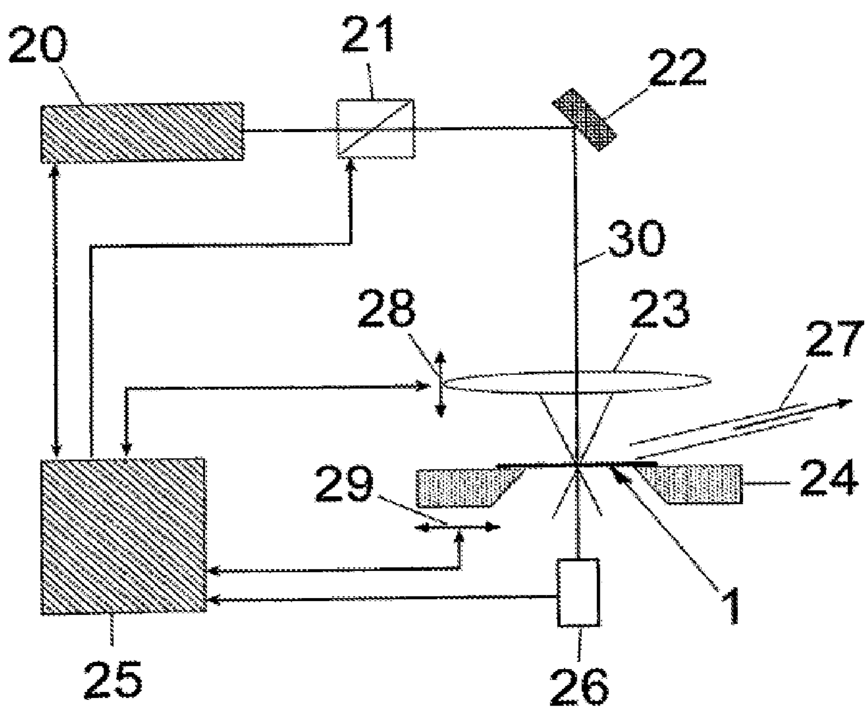
2. I have reviewed the above captioned application and claims. A copy of the current claims, as amended by Amendment (D) filed herewith, are attached hereto as an Appendix. In this declaration, I submit my expert opinion regarding the scope of the subject matter disclosed by the Blakey Patent (U.S. Patent 7,316,067 B2).

3. In rendering my opinion, I have considered the claims of the above-captioned application as listed in the attached Appendix, the specification and drawings of the above-captioned application, and I have also reviewed the Office Action issued in the above-captioned application by the Examiner on September 14, 2009, and I have reviewed the disclosure of U.S. Patent 7,316,067 B2 issued to Blakey (of record, and hereafter referred to as the "Blakey Patent"). I believe that the materials listed above, which I have considered, are sources of information an expert in my field would reasonably rely upon in rendering an opinion regarding the subject matter of this declaration.

4. The Blakey Patent discloses "forming a perforate membrane by laser drilling and a subsequent electro-polishing step," which pertains to a method of forming a perforate membrane (1) for use in a liquid transport device, wherein the membrane has at least plural nozzles (10) formed therethrough (See Abstract of the Blakey Patent, and Figure 1a). According to the Blakey Patent, each of the nozzles has a throat portion (12) opening at an opposite end through an opposite surface (2') of the perforate membrane, and a smoothly curved outwardly diverging portion (11) extending from the first end of the throat portion to the first surface (2) of the perforate membrane (See Abstract of the Blakey Patent, and Figure 1b). Laser energy is applied selectively to the first surface (2) of the membrane in the form of a pulsed, focused beam to form the nozzles (10) and thereafter the first surface (2) of the membrane and the surface of the diverging portion (11) of the nozzles (10) are electro-polished to remove surface imperfections (See Abstract of the Blakey Patent). The electro-polishing is controlled so as to remove material from the surface of the diverging portion (11) of the nozzles to a depth less than the length of the throat portion (12), (See Abstract of the Blakey Patent).

5. In Figure 2, the Blakey Patent provides a schematic of a laser apparatus for creating nozzle apertures in a membrane (Blakey Patent, col. 11, lines 41-42). Figure 2 of the Blakey Patent is reproduced below.

Figure 2



6. The Blakey Patent describes, in col. 13, the laser set-up shown in Figure 2, which employs a laser (20) to drill holes in a membrane (1). The laser disclosed by Blakey is able to produce pulses with an energy of 10 mJ in 10 ns (Blakey Patent, col. 13, lines 62-64). This corresponds to a pulse peak power of 1 MW (i.e., $(10 \times 10^{-3}$ J)/$(10 \times 10^{-9}$ s $= 1 \times 10^{6}$ W).

7. Based on my knowledge and experience in the art, pulse peak powers of such a magnitude (i.e., about 1×10^{6} W) <u>at pulse energies in the mJ level</u>, as is reached by the laser apparatus disclosed by the Blakey Patent, can only be reached with Q-switched lasers.

Therefore, I conclude that the laser apparatus disclosed by the Blakey Patent must inherently be a Q-switched laser that employs a Q-switch to generate primary pulses

8. Based on my personal knowledge and experience in the art, I know that a Q-switch is an optical modulator placed inside of the resonator in order to switch the Quality ("Q-factor") of the resonator very fast from low (i.e., high losses, low Q-factor) to high (i.e., low losses, high Q-factor), (See e.g., *Q-switched Lasers*, Encyclopedia of Laser Physics and Technology, *at* http://www.rp-photonics.com/q_switched_lasers.html, downloaded January 5, 2010, 6 pages, filed herewith as "Exhibit B," and *Q Factor*, Encyclopedia of Laser Physics and Technology, *at* http://www.rp-photonics.com/q_factor.html, downloaded January 5, 2010, 3 pages, filed herewith as "Exhibit C"). As long as the Q-factor is low, the pump energy is stored in the laser material. If the Q-factor is switched to high, then the whole stored energy is emitted in a very short time (e.g., in the range of nanoseconds). For a Q-switched laser, the pulse duration is orders of magnitude shorter than the pump duration.

9. The solution of the "laser machining device," according to the invention of independent claims 12 and 29 of the above-captioned application, is to employ a "resonator [that] generates, without a Q switch, primary pulses having a length within or greater than the microsecond range," as recited by the independent claims (See also the specification of the above-captioned application, page 2, line 23, to page 3, line 4). However, as discussed above, the laser (20) disclosed by the Blakey Patent inherently is a Q-switched laser that employs a resonator containing a Q-switch in order to generate primary pulses. In addition, the duration of the emitted laser pulses, in accordance with the invention of the above-captioned application, are in the range of 1 μs or greater, and correspond to the duration of the pump pulses of the pumping means. The duration of the emitted laser pulses of the

apparatus disclosed by the Blakey Patent is, of course, on the order of 10 ns, which is much shorter than the duration of the pump pulses.

10. In view of the above facts, I conclude that the Blakey Patent does not teach, or suggest, a resonator that generates primary pulses without the use of a Q switch. I also conclude that the Blakey Patent does not teach, or suggest, generating primary pulses having a length within or greater than the microsecond range. Therefore, I conclude that the Blakey Patent does not teach, or suggest, a "resonator [that] generates, <u>without a Q switch</u>, <u>primary pulses having a length within or greater than the microsecond range</u>," as recited by independent claims 12 and 29.

11. The Blakey Patent discloses the use of a Pockel's cell (21), (Blakey Patent, col. 14, lines 6-17, and Figure 2), but it has a completely different functionality in the apparatus disclosed by the Blakey Patent than the functionality the "modulation means" has in the claimed invention of the present application. More specifically, a Pockels Cell is a device that contains a photo refractive electro-optic crystal, which can change the polarization or phase of the light beam when a voltage is applied to the crystal (See, e.g., *Pockels Cell*, DiracDelta Science & Engineering Encyclopedia, *at* <u>http://www.diractdelta.co.uk/science/source/p/o/pockels%20cell/sour...</u>, downloaded July 16, 2009, 2 pages, of record). A Pockels Cell acts like a variable wave retarder plate by changing the polarization of the input laser beam when voltage is applied to the Pockels Cell, and, with the addition of a polarizer at the output, then intensity modulation of the light beam may be achieved (See, e.g., *Pockels Cell*, DiracDelta Science & Engineering Encyclopedia, *at* <u>http://www.diractdelta.co.uk/science/source/p/o/pockels%20cell/sour...</u>, downloaded July 16, 2009, 2 pages).

12. According to the Blakey Patent, the Pockels cell (21) is a modulator used for two purposes. First, it is able to block the laser beam, and to (i) let pass a defined number of pulses onto the work piece (Blakey Patent, col. 13, lines 58-62). The Pockels cell (21) is thus switched to open the beam path before the first needed pulse and to block again the beam path after the defined number of pulses, usually 20, has passed (Blakey Patent, col. 13, line 64, col. 14, line 2). Secondly, the Pockels cell (21) is used for (ii) attenuation. The Blakey Patent discloses, at col. 14, lines 9-17, that there is a second parameter set provided with a reduced peak energy of 15 μJ per pulse in 10 ns. Because there is an apparent need to keep the pulse duration constant at 10 ns, this can only be realized by the use of an external modulator, such as the Pockels cell, because decreasing the pump power would result in longer pulse durations as would be understood by those skilled in the art.

13. On the other hand, the purpose of the "modulation means" recited by independent claims 12 and 29 of the above-captioned application is to cut out parts of the primary pulses (1 μs or longer). In claim 28, the modulation means, in accordance with a particular non-limiting embodiment of the present invention, comprises a Pockels cell. Thus, in contrast to the disclosure of the Blakey Patent, the modulation means, such as for example a Pockels cell, of the present invention is switched several times during the laser pulse to generate a pulse train (See, e.g., Specification of the above-captioned application, page 4, lines 1-4 and lines 19-23). According to the Blakey Patent, however, the pulse train is generated by the laser (20) itself and not by the external Pockels cell modulator (21), (Blakey Patent, col. 13, lines 51-62).

14. In view of the above facts, I conclude that the Blakey Patent does not teach, or suggest, using a Pockels cell, or any other modulation means, to output a train of secondary pulses for each primary pulse entering the Pockels cell (21) from the laser (20). Therefore, I conclude that the Blakey Patent does not teach, or suggest, that "modulation means receives primary pulses from said resonator and <u>operates to output a train of secondary pulses for each primary pulse entering therein</u> from said resonator," as recited by independent claims 12 and 29.

<u>Summary</u>

15. It is my expert opinion, based on the materials and evidence I have considered, that:

a. the "laser machining device" according to the above-captioned application employs a pulsed laser and not a Q-Switch laser as is clearly described in the original specification of the above-captioned application on page 1, lines 7-11, and on page 1, line 27, to page 2, line 8, and on page 2, line 30, to page 3, line 7, and the laser pulses are generated by controlling the pumping means in a pump mode;

b. the Blakey Patent discloses a laser apparatus that inherently employs a Q-Switch laser head because Q-Switching technology is needed to achieve the pulse peak powers of high magnitude of about 1×10^6 W disclosed by Blakey;

c. the Q-Switch laser head disclosed by the Blakey Patent, col. 13, line 58, to col. 14, line 2, is provided with an external modulator, such as a Pockels cell, but the external modulator is used as a switch to stop the pulses

generated by the laser head and to allow a given number of the pulses generated by the laser head to pass through for drilling a specific hole;

d. the external modulator, such as the Pockels cell, disclosed by the Blakey Patent is not used to modulate each pulse of a primary pulse train generated by the laser to output a train of secondary pulses; and

e. the Blakey Patent does not teach, or suggest, (i) a "resonator [that] generates, without a Q switch, primary pulses having a length within or greater than the microsecond range," and (ii) that "modulation means receives primary pulses from said resonator and operates to output a train of secondary pulses for each primary pulse entering therein from said resonator," as recited by independent claims 12 and 29 of the above-captioned application.

16. I declare under penalty of perjury that the foregoing is true and correct, that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements so made are punishable by fine or imprisonment, or both, under 18 U.S.C. § 1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Signed by,

Date: February 11, 2010 Valerio Romano

Name: V. Romano

APPENDIX:

Claims 1-11 have been cancelled.

12. A laser machining device for drilling holes in fluid injection device components, particularly for injecting fuel into a combustion engine, said machining device comprising:

(a) a laser resonator formed of a first solid state active medium and first optical pumping means, wherein said first optical pumping means is formed by laser diodes and said resonator generates, without a Q switch, primary pulses having a length within or greater than the microsecond range; and

(b) modulation means arranged between said resonator and a machining head, wherein said modulation means receives primary pulses from said resonator and operates to output a train of secondary pulses for each primary pulse entering therein from said resonator, and each secondary pulse has a shorter length than the corresponding primary pulse.

13. (Previously Presented) The laser machining device according to claim 12, further comprising an optical diode arranged downstream of said resonator.

14. (Previously Presented) The laser machining device according to claim 12, further comprising means for amplifying the pulses supplied by said resonator.

15. (Previously Presented) The laser machining device according to claim 13, further comprising means for amplifying the laser pulses supplied by said resonator, said amplification means being arranged downstream of said optical diode.

16. (Previously Presented) The laser machining device according to claim 13, wherein said optical diode is formed by a linear polarizer and by a quarter-wave plate arranged following said polarizer.

17. (Previously Presented) The laser machining device according to claim 15, wherein said optical diode is formed by a linear polarizer and by a quarter-wave plate arranged following said polarizer.

18. (Previously Presented) The laser machining device according to claim 14, wherein said amplification means are controlled so that amplification pulses are provided with a time lag relative to the primary pulses so that the amplitude of said secondary pulses is modulated.

19. (Previously Presented) The laser machining device according to claim 15, wherein said amplification means are controlled so that amplification pulses are provided with a time lag relative to the primary pulses so that the amplitude of said secondary pulses is modulated.

20. (Previously Presented) The laser machining device according to claim 14, wherein said amplification means include a cavity formed by a second solid state active medium and by second optical pumping means formed by a flash lamp.

21. The laser machining device according to claim 18, wherein said amplification means include several active mediums defining several amplification levels, each of said active mediums being pumped by a flash lamp.

22. The laser machining device according to claim 12, wherein said resonator is arranged for supplying at the outlet thereof a linearly polarized laser beam.

23. The laser machining device according to claim 21, wherein said first active medium is formed by a crystal selected from among crystals that directly generate a linearly polarized light.

24. The laser machining device according to claim 12, wherein said resonator supplies primary pulses in the microsecond range having an energy such that a hole is drilled in a given component by a single primary pulse generated by said resonator.

25. The laser machining device according to claim 12, wherein each of the primary pulses has a length between fifty microseconds (50 μs) and one millisecond (1 ms).

26. The laser machining device according to claim 12, wherein each of the secondary pulses has a length between one microsecond (1 μs) and twenty microseconds (20 μs).

27. The laser machining device according to claim 25, wherein each of the secondary pulses has a length between one microsecond (1 μs) and twenty microseconds (20 μs).

28. The laser machining device according to claim 12, wherein said modulation means comprises a Pockels cell.

29. A laser machining device for drilling holes in fluid injection device components, particularly for injecting fuel into a combustion engine, said machining device comprising:

(a) a laser resonator formed of a first solid state active medium and first optical pumping means, wherein said first optical pumping means is formed by laser diodes and said resonator generates, without a Q switch, primary pulses having a length within or greater than the microsecond range;

(b) modulation means arranged between said resonator and a machining head, wherein said modulation means receives primary pulses from said resonator and operates to output a train of secondary pulses for each primary pulse entering therein from said resonator, and each secondary pulse has a shorter length than the corresponding primary pulse; and

(c) means for amplifying the pulses supplied by said resonator, wherein said amplification means are controlled so that amplification pulses are provided with a time lag relative to the primary pulses so that the amplitude of said secondary pulses is modulated, and wherein said amplification means include several active mediums defining several amplification levels, wherein each of said active mediums is pumped by a flash lamp, wherein said first active medium is formed by a $Nd:YVO_4$ crystal that directly generates a linearly polarized light.